viewed from a different point of view in the visual image. Furthermore, the therapeutic instrument often blocks the practitioner's direct view of the ROI with the imaging tool, making highly accurate therapies quite difficult for the medical practitioner to achieve. Significant amounts of training and practice are required to overcome these difficulties, as well as the capability to work with a reduced sense of touch that is conveyed through the shaft of an instrument having friction and a non-intuitive pivot at the point of entry. Thus, to work effectively with current imaging and therapeutic technologies, the practitioner of MIMPs must be highly trained and skilled.

[0010] Clearly, there is a need for an instrument that integrates imaging, diagnostic, and therapeutic functions, delivers these functions through a relatively small diameter, and is sufficiently intuitive to use as to require little training or skill. Ideally, the instrument should be implemented using a single optical fiber, but should still be capable of providing a sufficient FOV, good image size, and resolution, and should ensure that the ROI within a patient's body while administering therapy corresponds to that during imaging. Currently, none of the instruments available provide these capabilities and cannot be easily modified to provide such capabilities.

SUMMARY OF THE INVENTION

[0011] In accord with the present invention, apparatus is defined for selectively providing imaging, monitoring, sensing, screening, diagnosis, and therapy for an ROI in a patient. The apparatus preferably includes at least one light source. For example, a light source may be used to provide both an illumination light for imaging light, while another light source produces light of a substantially different characteristic than the imaging light for other uses. Or, the same light source can be used for both imaging and the other purpose. Also included is a light guide having a proximal end and a distal end. (Note that in the claims that follow, the term "light guide" or its plural form is used, and these terms will be understood to encompass optical fibers, thin film optical paths, and other devices and constructs for conveying light along a desired path.) The one or more light sources are optically coupled to the proximal end of the light guide, and the distal end of the light guide is adapted to be positioned adjacent to an ROI. A scanning actuator is disposed adjacent to the distal end of the light guide and causes the light from the one or more light sources that are conveyed through the light guide to scan the ROI. A light detector receives light from the ROI, producing a signal corresponding to an intensity of the light for use in producing an image of the ROI. Also included are a display on which the image of the ROI can be visualized by a user, and a control circuit that is operatively coupled to control the scanning actuator, the one or more light sources, and the light guide. The control circuit selectively energizes the one or more light sources to image the ROI and render at least one other function to the ROI. The other functions include diagnosing a condition, rendering therapy, sensing a condition, and monitoring a medical procedure—all in regard to the ROI.

[0012] In one embodiment of the present invention, a plurality of light sources emit light of different colors. The apparatus then further includes a combiner that combines the light of different colors emitted by the plurality of light sources for input to the proximal end of the light guide. Also, for this embodiment, the light detector includes a plurality of light sensors that are each sensitive to one of the different colors of light emitted by the plurality of light sources. In one form of this embodiment, the plurality of light sensors are disposed adjacent to the distal end of the light guide, while in another form of the embodiment, a plurality of light guides convey the imaging light reflected from the ROI to the plurality of light sensors. A pseudo-stereo image of the ROI can be visualized by a user, by employing different portions of the plurality of light guides to convey the light reflected from spaced-apart areas in the ROI. A stereo display is then preferably included to enable a user to visualize the pseudo-stereo image of the ROI.

[0013] One form of the scanning actuator includes a pair of electromechanical actuators that respectively move the distal end of the light guide in substantially transverse directions. In another embodiment, the scanning actuator comprises a piezoceramic actuator that is energized at a harmonic of a resonant frequency of the distal end of the light guide or electromechanical actuator.

[0014] In one configuration, the light guide comprises an optical fiber, and the distal end of the optical fiber is tapered to a substantially smaller cross-sectional size than a more proximal portion of the optical fiber, producing a tapered end that emits light having a substantially smaller point spread function (PSF) than light that would be emitted from a non-tapered end of an optical fiber.

[0015] In most embodiments of the present invention, at least one lens is disposed between the distal end of the light guide and the ROI, for focusing the imaging light and the light produced by the therapy light source onto the ROI. Preferably, to provide high resolution and a good FOV, a lens is mounted on the distal end of the light guide in one embodiment. In this configuration, as the scanning actuator drives the distal end of the light guide in a resonance mode to scan the ROI, the lens that is mounted on the distal end of the light guide has sufficient mass so that the lens generally rotates about a center of the lens as the light guide moves. The movement of the light guide changes the direction in which light is emitted from the lens, to scan the ROI.

[0016] In yet another embodiment, the light guide comprises a thin film optical waveguide that is optically coupled to the distal end of the light guide so that light emitted by the at least one light source is directed onto the ROI. The scanning actuator is then disposed adjacent to the thin film optical waveguide and moves the thin film optical waveguide, to cause the light to scan the ROI. Preferably, the thin film optical waveguide has a cross-sectional size less than 0.01 mm. It is also contemplated that a plurality of thin film optical waveguides can be used in parallel to convey light to and from the ROI.

[0017] In one embodiment, a polarizing filter is disposed between the at least one light source and the ROI, so that the ROI is illuminated with a polarized illumination light. For this embodiment, the light detector detects polarized light having a predefined axis of polarization.

[0018] In still another embodiment, the at least one light source provides one or more of a visible light, an ultraviolet (UV) light, and an infrared (IR) light as the illumination light. In connection with this embodiment, the light detector